

## Clinical Problems in Cardiology

RYAN FRIES, DVM, DACVIM (CARDIOLOGY)  
CLINICAL ASSISTANT PROFESSOR CARDIOLOGY  
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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### Case 1: Cooter

- Signalment: 5 year old, MI catahoula leopard dog
- History: presenting for acute collapse, working farm dog in rural Texas
- Medical history: inconsistent history of vaccinations, heartworm preventative, or deworming
- Veterinary history: last veterinary visit 2 years ago, everything was fine according to owner




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### Case 1: Cooter

- Physical Exam
  - Dull mentation but responsive
  - Mucous membranes pale pink, CRT 2 seconds
  - Lung sounds increased diffusely
  - Grade V/VI left basilar murmur
  - Irregular heart rhythm
  - Bounding femoral pulses with frequent pulse deficits
  - Temperature: 103.1 F
  - Heart rate: 166 bpm
  - Respiratory Rate: 80 bpm

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### Case 1: Cooter

- Diagnostic Tests

- Blood pressure
  - 112 mmHg systolic (#5 cuff, left front)
- CBC
  - WBC 35.43 (normal 6.00-17.00)
  - Bands 7.0 (normal 0-0.3)
  - Neutrophil 29.33 (normal 3.00-11.50)
- Chemistry
  - BUN 46 (normal 6-30)
  - Creatinine 1.3 (normal 0.5-1.5)
  - ALT 455 (normal 8-65)
  - Total Bilirubin 0.46 (normal 0.1-0.3)
  - Glucose 60 (normal 68-126)

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### Case 1: Cooter

- Diagnostic Tests

- Urinalysis
  - Specific gravity 1.011
  - Protein 3+
  - WBC negative

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### Case 1: Cooter

- Electrocardiogram



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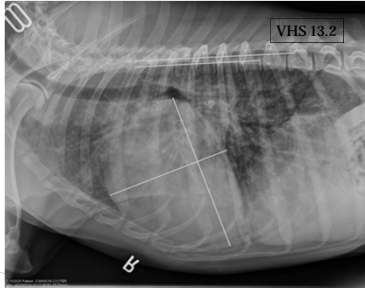
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### Case 1: Cooter

#### • Thoracic Radiographs




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### Case 1: Cooter

#### • Additional Diagnostics Recommended

1. Echocardiogram
2. Blood cultures
3. Urine culture
4. Cardiac troponin I (cTnI)
5. Chaga's titer
6. Possible bronchoscopy with alveolar lavage
7. Possible abdominal ultrasound

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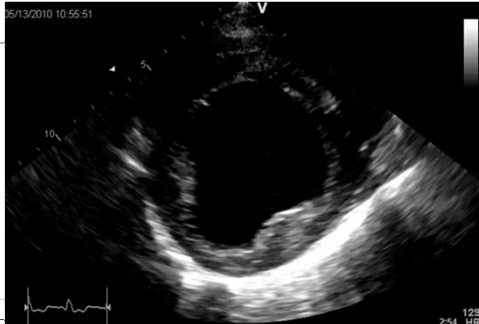
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### Right parasternal – LV Short Axis




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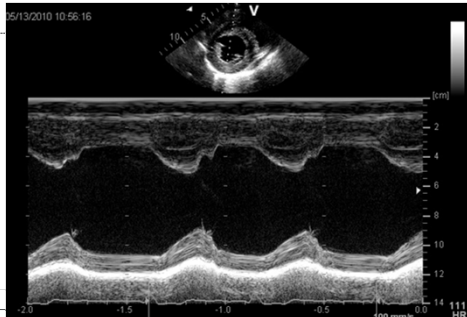
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Right parasternal – LV M-mode



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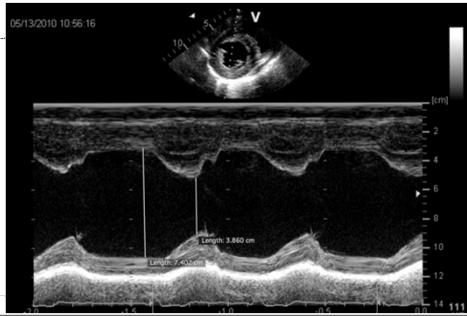
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Right parasternal – LV M-mode



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Right parasternal – Short Axis LA:Ao



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Right parasternal – Long Axis 4 Chamber



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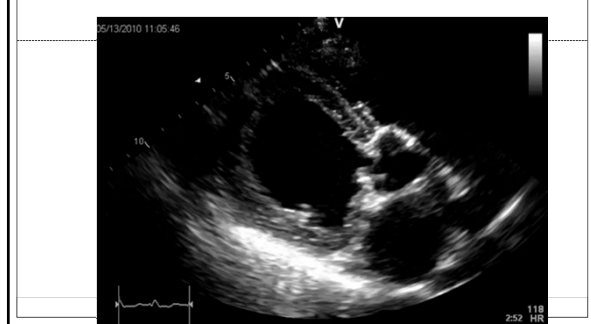
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Right parasternal – Inflow/Outflow



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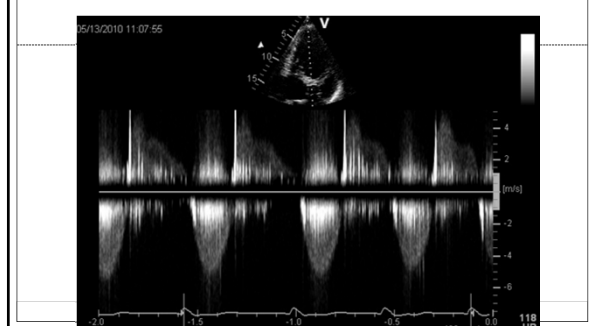
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Subcostal – Transaortic Velocities



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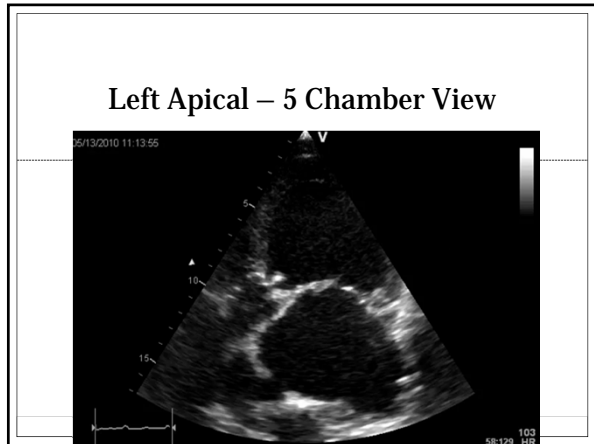
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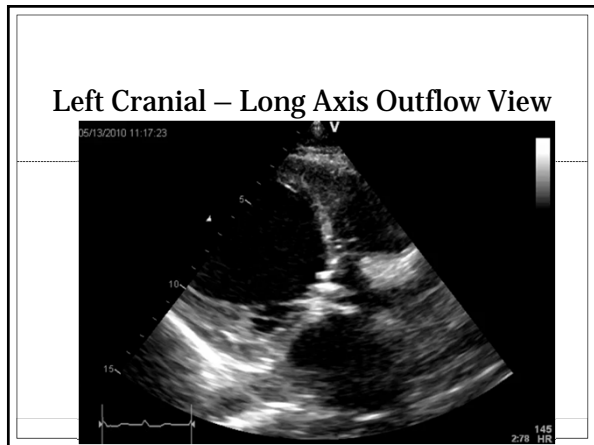
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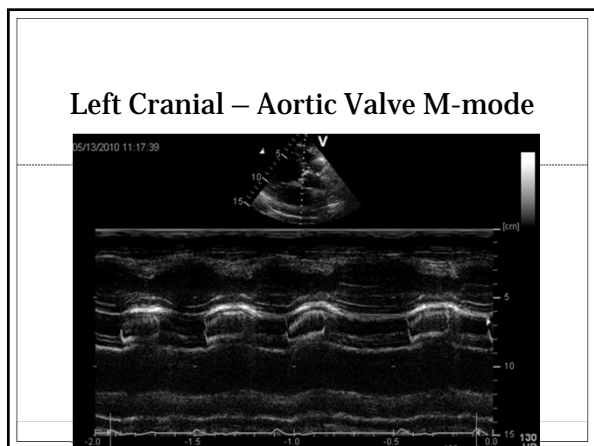
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### Case 1: Cooter

- **Treatment**
  - Congestive heart failure
    - Furosemide
    - Pimobendan
  - Endomyocarditis
    - Ampicillin (susceptible)
    - Enrofloxacin (susceptible)
  - Ventricular arrhythmias
    - Lidocaine
    - Procainamide

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### Case 1: Cooter

- **Endocarditis**
  - Uncommon in dogs
  - Affects left-sided valves
  - Typically larger (male) breeds
  - Predisposed by subvalvular aortic stenosis

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### Case 1: Cooter

- **Pathogenesis of BE**
  - Portal of entry
  - Bacterial adhere directly to valves (virulence of microorganism) or agglutinate, inoculating the valve or endocardial surface
  - Infection most often begins on surface facing flow of blood
    - Previous injury to valve or endocardial surface predisposes to colonization
  - Vegetation forms, consisting of:
    - Bacterial colonies
    - Thrombus formation (platelets, thrombin, and fibrin)
    - Inflammatory cells
    - Attempts at healing (granulation tissue, fibrosis)

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### Case 1: Cooter

#### • Common Isolates in Dog

- Streptococcus
- Pseudomonas aeruginosa
- Anaerobic bacteria
- Staphylococcus
- Escherichia coli
- Actinomyces
- Bartonella spp (vinsoni) – culture negative, aortic endocarditis
- Corynebacterium spp
- Erysipelothrix rhusiopathiae (tonsillarum)

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### Case 1: Cooter

#### • Pathophysiology

- Bacteremia and inflammation = fever and sick
- Sepsis can progress to septic shock / SIRS
- Thromboembolic injury to other tissues
  - Septic or Bland (sterile) thromboemboli
- Metastatic infection of other tissues
  - Kidney, CNS, joints, bone
  - Embolic pneumonia (especially with right sided infections)
- Immune-mediated phenomena
  - Polyarthritis
  - Glomerulonephritis
  - Vasculitis
- Cardiac injury

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### Case 1: Cooter

#### • Cardiac Injury in Infective Endocarditis

- Valve Injury
  - Valvular incompetency – MR, AR
  - Possible stenosis
- Myocarditis
- Myocardial infarction
- Arrhythmias
  - Ventricular ectopy
  - AV Block (periaortic abscess)
- Cardiomegaly
  - Volume overload
- Congestive heart failure

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### Case 1: Cooter

- Possible Clinical Findings with IE
  - Prior or current infection
  - Immunosuppressive diseases or medications
  - Fever
  - Polyarthritits
  - Constitutionally ill
  - New heart murmur
    - Diastolic component with aortic
  - Signs of vasculitis
    - Cutaneous hemorrhage, thrombosis
  - Other cardiac findings
    - Tachycardia
    - Hyperkinetic or bounding femoral pulses
    - Arrhythmias
    - Signs of congestive heart failure

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### Case 1: Cooter

- Bacterial Endocarditis Therapy
  - Antibiotic therapy
    - Bactericidal & penetrates fibrin
    - IV therapy initially (7-14 days), long term therapy (6-8 weeks minimum, may be life long)
    - Should be based on culture results whenever possible
  - Intitial & Emperical Therapy
    - Consider common isolates
    - If response to therapy not observed in 48-72 hrs, need to change
    - IV cephalosporin or ampicillin (+ clavulanate)
    - Amikacin
    - Enrofloxacin
    - 3<sup>rd</sup> generation cephalosporin (cefotaximine) or imipenem
    - Azithromycin for suspected or confirmed Bartonella
    - Clindamycin or metronidazole for suspected anaerobic infection
  - Antiplatelet drugs?

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### Case 1: Cooter

- Prognosis
  - Overall the prognosis of IE is guarded to poor
    - Majority of animals succumb to heart failure or secondary embolic event
    - Mitral valve endocarditis probably has a better prognosis than aortic valve
  - Bacteriologic cure may be obtained, but permanent valvular lesions and cardiac dysfunction may persist and progress to CHF
  - Except in the most minor cases, the valve usually incurs permanent functional damage

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### Case 1: Cooter

#### • Prevention

- No studies of risk-benefit and no standards
- Risk factor uncertain other than for dogs with SAS and possibly left to right shunts
- No evidence of BE risk in dogs with dental disease though bacteremia is common

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### Case 1: Cooter

#### • Outcome

- Cooter spent 48 hours in the hospital
- Discharged (5/16/10) on the following medications
  - Furosemide
  - Pimobendan
  - Benazepril
  - Spironolactone
  - Clavamox
  - Enrofloxacin
- No follow up ever elected
- Owner called to inform me that Cooter died in his arms on Christmas morning

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### Case 2: Applejack

**12 YEAR OLD MALE NEUTERED  
MINIATURE SCHNAUZER  
"APPLE JACK"**




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### History

- 1 week history of collapsing
- 2 events were preceded by excitement and 1 event occurred while on a walk
- Up to date on vaccines, receives monthly heartworm, flea, and tick preventative

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### Description of Event

- 1<sup>st</sup> two events: Applejack was barking through the window at the mailman then fell off the back of the couch
- Was limp and urinated on the floor
- The event lasted 20 seconds then Applejack resumed barking at the mailman
- 2<sup>nd</sup> event: while walking up a hill Applejack stopped, stumbled, then fell to the ground limp

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### Physical Exam

- Bright, alert and responsive
- Mucous membranes pink, CRT < 2 seconds
- Lung sounds increased bilaterally
- Grade V/VI right apical systolic murmur
- Irregular heart rhythm
- Strong synchronous femoral pulses
- Normal cranial nerve exam
- Normal conscious proprioception and reflexes

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### Problem List / Differentials

- Collapse
  - Seizure
  - Syncope
- Murmur
  - Consistent with tricuspid regurgitation or a ventricular septal defect

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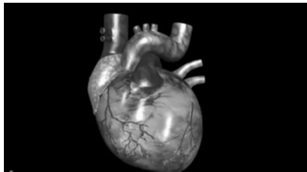
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### Heart vs Head

- Which is more likely at this time?
  - History
  - Physical Exam




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### Historical Clues

- Occurs with activity: favors syncope
- Limp: favors syncope
- Urination: favors neurologic, but could be either
- Fast recovery: favors syncope
- Loud murmur: favors syncope
- Arrhythmia: favors syncope

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### Diagnostic Tests

- Blood pressure
  - 114 mmHg systolic (Doppler #3 cuff, left front)
- CBC
  - Stress leukogram
- Chemistry
  - ALP 423, Cholesterol 232, Triglycerides 700
- Urinalysis
  - 2+ protein
  - USG 1.023

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### Diagnostic Tests

- Echocardiogram




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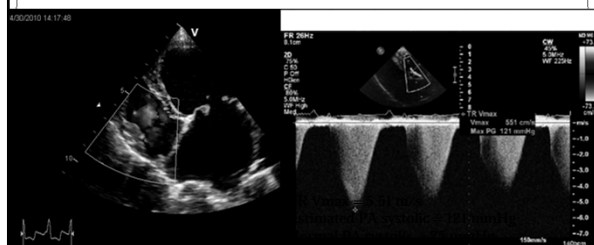
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### Diagnostic Tests

- Echocardiogram



Tricuspid regurgitation

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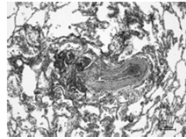
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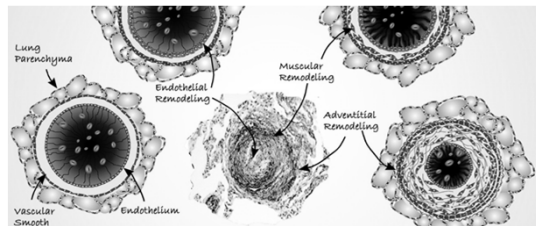
## Pulmonary Hypertension

- Smaller arteries, arterioles, and capillaries are the primary pulmonary resistance vessels. If injured by thrombi, inflammation, parasites, chronic hypoxia, or shear stress due to excessive blood flow:

1. Reactive vasoconstriction
2. Medial hypertrophy
3. Intimal proliferation
4. "Tumorlets" (plexiform lesions)



Hypertension



## Pulmonary Hypertension

- Does not refer to a disease itself but is a description of the hemodynamic consequences of various conditions that lead to a chronic increase in pulmonary artery pressure.

- Systolic PAP: > 35 mmHg
- Diastolic PAP: > 15 mmHg
- Mean PAP: > 25/30 mmHg (at rest/exercise)

## Epidemiology

- **Primary pulmonary hypertension**
  - Genetic disease characterized by marked vasoconstrictive tendency
  - Endothelial dysfunction
  - Rare
- **Secondary pulmonary hypertension**
  - Numerous etiologies
  - Common

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## Etiology of Secondary PH

- **Pre-capillary**
  - Increased flow: cardiac shunts, exercise, hyperthyroidism
  - Increased arteriolar resistance: PTE, HW fibrosis, polycythemia
- **Capillary**
  - Loss of lung tissue
  - PTE, pneumonia
- **Post-capillary**
  - Impedance of pulmonary venous drainage
    - Left sided heart disease
    - Typically seen in horses and cats




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## Diagnosis

- Echocardiogram
- CT Angiography
- Cardiac Catheterization
- Ventilation-perfusion scintigraphy

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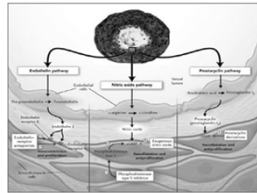
## Management of PH

- **Correct underlying cause**
  - Close PDA
  - Treat left sided CHF
  - Treat respiratory infection, asthma
  - Control thromboembolism
- **Increase RV cardiac output**
  - Pimobendan
- **Reduce volume overload**
  - Diuretics
  - Low salt diet

[illegible]

## Management of PH

- Decrease pulmonary vascular resistance
  - Vasodilators
    - Oxygen
    - PDE-5 inhibitors (Sildenafil, Viagra)
    - NO donors (L-arginine)
    - Drugs not well established in vet med (*Prostanoids, Endothelin Receptor Antagonists, Guanylate Cyclase Stimulators, Imatinib – Cleavec*)
  - Bronchodilators (controversial issue)
  - Decrease blood viscosity (phlebotomy, hydroxyurea)



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## Prognosis

- **People:**
  - Poor (2.8 years for Primary PH)
- **Animals:**
  - No systematic data available
  - 1 study: treatment for PH (4 months)
  - Prognostic indicators
    - Severity of PH
    - Cor Pulmonale
    - Responsiveness to management
    - Underlying disease process
    - Right heart function

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### Case 3: Daisy

**12 YEAR OLD FEMALE SPAYED  
MINIATURE SCHNAUZER  
"DAISY"**




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### History

- 2 week history of collapsing
- The events are preceded by excitement
- First event occurred when the owners came home from work – Daisy jumped off the couch then stumbled and fell to the floor
- Up to date on vaccines, receives monthly heartworm, flea, and tick preventative

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### Description of Event

- 1<sup>st</sup> event: Daisy jumped off couch and ran towards owners, stumbled and then fell
- Was at first limp, then started paddling and vocalizing
- Needed help standing, stumbled again but didn't fall
- Daisy acted strange for the next 15 minutes then seemed normal

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### Description of Event

- 2<sup>st</sup> event: Daisy ran for a squirrel and chased it up a tree, then turned towards the house and fell in the middle of the yard
- Was initially limp as before, then paddling followed by vocalizing
- Owners carried her into the house and rushed her to the veterinarian
- Daisy appeared normal by the time they reach the veterinarian

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### Physical Exam

- Bright, alert and responsive
- Mucous membranes pink, CRT < 2 seconds
- Lung sounds clear bilaterally
- Grade III/VI left apical systolic murmur
- Regularly irregular heart rhythm
- Strong synchronous femoral pulses
- Normal cranial nerve exam
- Normal conscious proprioception and reflexes

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### Problem List / Differentials

- Collapse
  - Seizure
  - Syncope
- Murmur
  - Consistent with mitral regurgitation (CVD)
- Arrhythmia
  - Suggestive of sinus arrhythmia

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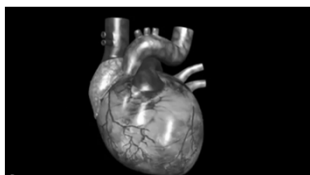
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### Heart vs Head

- Which is more likely at this time?
  - History
  - Physical Exam




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### Historical Clues

- Occurs with activity: favors syncope
- Limp: favors syncope
- Disorientation post event: favors neurologic
- Paddling
  - Tonic-clonic: neurologic
  - Broad, sweeping paddling: can be syncope during recovery
- Arrhythmia: favors syncope

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### Let's dig a little deeper

- Was Daisy acting strange before the events?
  - No she was just excited
- How long did the each event last?
  - 10 seconds
- Did Daisy urinate or defecate during the event?
  - No
- What did the paddling look like?
  - She paddled her front legs 2 or 3 times like she was swimming then stopped

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### Diagnostic Tests

- Blood pressure
  - 128 mmHg systolic (Doppler #3 cuff, left front)
- CBC
  - WNL
- Chemistry
  - WNL
- Urinalysis
  - WNL

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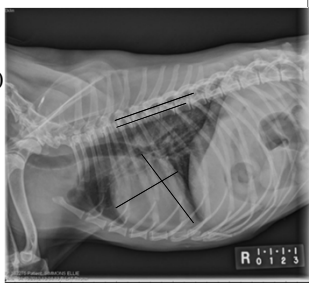
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### Diagnostic Tests

- Thoracic radiographs
  - VHS 10.3 (normal < 10.7)
  - Vasculature normal
  - Parenchyma normal
  - No masses




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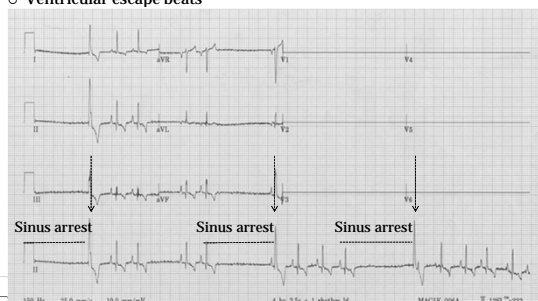
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### Diagnostic Tests

- Electrocardiogram
  - Sinus arrhythmia
  - Periods of sinus arrest
  - Ventricular escape beats




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### Electrocardiogram

- Evidence of sinus node dysfunction
- Sinus arrest < 2 seconds
- Suggestive of sick sinus syndrome but not conclusive
  - Rule out vagal disease vs sinus nodal disease

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### Atropine Response Test

- Give 0.04 mg/kg IV with anticipated response in 5-10 minutes
- Response to atropine
  1. Heart rate increases to > 160 bpm without further block/sinus arrest = secondary to high vagal tone
    1. GI Disease
    2. Respiratory Disease
    3. Neurologic Disease
    4. Ocular Disease
  2. Heart rate does not increase > 160 bpm and/or persistent block = SA nodal +/- AV nodal disease

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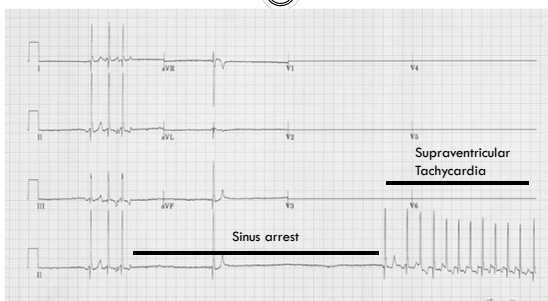
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### Atropine Response Test




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## Sick Sinus Syndrome

- Complex arrhythmia characterized by sinus node dysfunction with or without AV nodal involvement
- Classically described as “Brady-Tachy Syndrome”
- Usually requires a Holter monitor for definitive diagnosis
- High risk breeds
  - Miniature Schnauzer
  - Cocker Spaniel
  - West Highland White Terriers
  - Dachshund

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## Daisy's Holter Monitor

- 24 hour reading
  - 114,000 total beats
  - Average HR – 74 bpm
  - Highest HR – 155 bpm
  - Slowest HR – 22 bpm
  - # of Pauses – 2345
  - Longest Pause 9.6 seconds
- Interestingly the owners did not report any clinical signs while Daisy wore the Holter




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## Treatment

- Sick Sinus Syndrome
  - Permanent pacemaker
  - Drugs (unreliable)
    - Theophylline
    - Terbutaline
    - Anti-cholinergic




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### Prognosis

- Pacemaker
  - Good to excellent

Washington Post (July 28, 2014):

- Dog passes from overwhelming joy when sees owner after 2 years.
- "The Schnauzer, Casey, was taken to the vet, the vet saw the video, and said everything is fine with her." "No worries."




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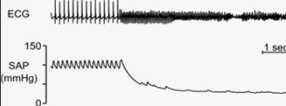
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### Arrhythmogenic Causes of Syncope

<b>Bradyarrhythmias</b>	<b>Tachyarrhythmias</b>
<ul style="list-style-type: none"> <li>• Sick Sinus Syndrome</li> <li>• Sinus Arrest</li> <li>• Atrial Standstill</li> <li>• AV Nodal Block                             <ul style="list-style-type: none"> <li>○ High Grade 2<sup>nd</sup> Degree</li> <li>○ 3<sup>rd</sup> Degree</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Supraventricular Tachycardia                             <ul style="list-style-type: none"> <li>○ Atrial fibrillation</li> <li>○ Atrial flutter</li> <li>○ Focal atrial tachycardia</li> <li>○ Circus movement tachycardia</li> </ul> </li> <li>• Ventricular Tachycardia</li> </ul>

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### Case 4: Reuben

- Signalment: 12 year old, MN Sphynx cat
- History: presenting for acute respiratory difficult, hiding, not eating
- Medical history: up to date on vaccines, heartworm preventative, one other indoor cat in household
- Veterinary history: no major medical issues




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### Case 4: Reuben

#### • Physical Exam

- Alert and responsive
- Mucous membranes pale pink, CRT 2 seconds
- Lung sounds decreased diffusely
- No murmur present
- Irregular heart rhythm
- Weak femoral pulses with frequent pulse deficits
- Temperature: 97.6 F
- Heart rate: 240 bpm
- Respiratory Rate: 80 bpm
- Abdominal distension
- Jugular pulses

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### Case 4: Reuben

#### • Problem List

1. Tachypnea/Dyspnea
2. Decreased lung sounds
3. Irregular heart rhythm (Arrhythmia)
4. Jugular pulses
5. Abdominal distension

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### Case 4: Reuben

#### • Diagnostic Tests

- Blood pressure
  - ✦ 78 mmHg systolic (#2 cuff, left front)
- CBC
  - ✦ WNL
- Chemistry
  - ✦ WNL

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### Case 4: Reuben

- Diagnostic Tests
  - Urinalysis
    - Specific gravity 1.040
    - Protein 3+

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### Case 4: Reuben

- Electrocardiogram




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### Case 4: Reuben

- Thoracic Radiographs




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### Case 4: Reuben

#### • Differential Diagnosis

1. Cardiomyopathy (HCM>RCM>DCM>ARVC>UCM)
2. Myocarditis
3. Neoplasia
4. Congestive Heart Failure
5. Infectious

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### Case 4: Reuben

#### • Additional Diagnostics Recommended

1. Echocardiogram
2. Thoracocentesis with fluid analysis and cytology
3. Cardiac troponin I (cTnI)
4. Possible CT
5. Possible abdominal ultrasound

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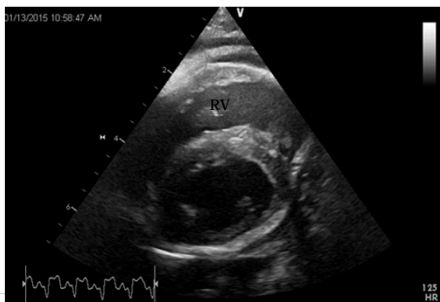
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### Echocardiogram




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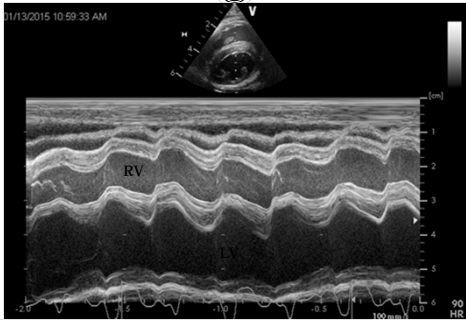
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Echocardiogram



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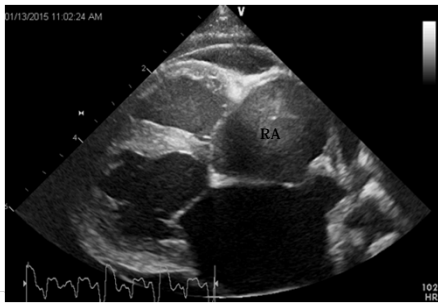
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Echocardiogram



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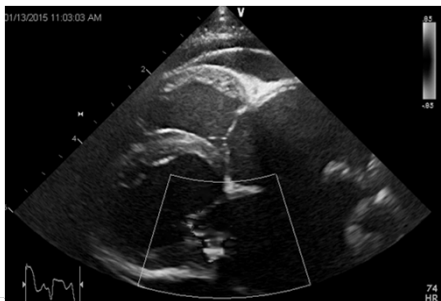
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Echocardiogram



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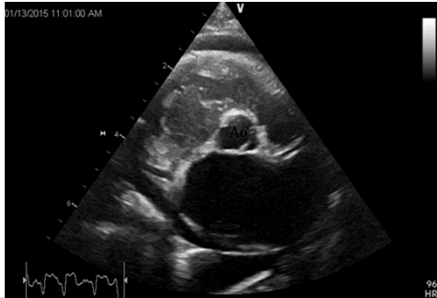
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### Echocardiogram




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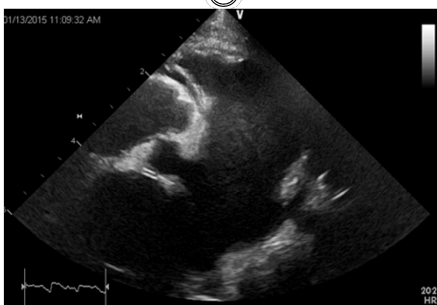
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### Echocardiogram




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### Echocardiogram

- Moderately enlarged LV in diastole and systole
- Decreased systolic function characterized by a normal interventricular septum and hypokinetic poorly contractile LV free wall
- Severe biatrial enlargement with mitral and tricuspid regurgitation
- Spontaneous echo-contrast in left auricle
- Mild to moderate pericardial effusion
- Mild pleural effusion
- Moderate ascites

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### Treatment

- **In-hospital**
  - Oxygen therapy
  - Furosemide 1-2 mg/kg IV as needed
  - Pimobendan 1.25 mg PO q 12 hours
  - Sotalol 5 mg PO q 12 hours
  - Thoracocentesis +/- abdominocentesis
- **Go-home**
  - Furosemide 6.25 mg PO q 12 hours (1.54 mg/kg)
  - Pimobendan 1.25 mg PO q 12 hours (0.3 mg/kg)
  - Sotalol 5 mg PO q 12 hours (1.2 mg/kg)
  - Plavix (Clopidogrel) 18.75 mg PO q 24 hours

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### Plan and Follow Up

- **Fluid Analysis and Cytology**
  - Modified transudate
  - Few small lymphocytes, no evidence of neoplasia or infection
- **Rechecks**
  - Recheck radiographs, blood pressure, and renal values in 7 days
- **Prognosis**
  - Overall prognosis for unclassified cardiomyopathy is poor
  - If response to therapy is good/excellent 6 months of good quality of life is expected
  - High risk for sudden death and arterial thromboembolism

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### 7 Day Recheck

- **History**
  - Reuben was doing very well for the first 5 days, but over the last 2 days he breathing has become deeper and more rapid again
  - Reuben has not been eating for the past 2 days
  - Reuben will not go upstairs
- **Physical Exam**
  - Temp: 100 F Pulse: 170 bpm (irregular) Resp: 60 bpm
  - Lung sounds are increased diffusely
  - Pulses weak
  - Jugular pulses present

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### Diagnostics

- Blood pressure
  - 106 mmHg (#2 cuff, left front limb)
- Chemistry
  - BUN 33 (6-30)
  - Creatinine 1.2 (0.5-1.5)
  - Potassium 3.9 (3.9-5.5)

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### Treatment

- Therapy
  - Increase furosemide to 6.25 mg PO q 8 hours (1.54 mg/kg)
  - Pimobendan, Sotalol, and Plavix to remain the same
- Follow Up
  - Recommend recheck in 7 days

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### Client Communication

- Owners called to give an update on Reuben: he is not eating well and his respiratory rates at home are in the 60's when he is sleeping
- Reuben will not go upstairs and seems uncomfortable
- Reuben is not as affectionate as he normally is

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### Recommendation

- **Therapy**
  - Furosemide increased to 12.5 mg PO q 8 hours (3.05 mg/kg)
  - Add Enalapril 1.25 mg PO q 12 hours (0.30 mg/kg)
  - Pimobendan, Sotalol, and Plavix unchanged
- **Follow Up**
  - Recommend to come in for thoracic radiographs

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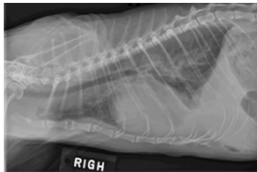
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### Diagnostics

- **Thoracic Radiographs**




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### Treatment

- **Therapy**
  - Discontinue Furosemide and Enalapril
  - Add Torsemide 1.25 mg PO q 12 hours
  - Continue Pimobendan and Plavix
- **Follow Up**
  - Recheck thoracic radiographs, blood pressure, and chemistry panel in 7 days

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### Follow Up

#### • History

- Reuben is eating and drinking normally. He has increased urination – had an accident while he was sleeping
- Reuben is playing with his housemate and going upstairs
- At home resting respiratory rates are in the low 30's

#### • Physical Exam

- Temp: 101.4 F Pulse: 166 bpm (irregular) Resp: 36 bpm
- Lung sounds are normal
- Pulses weak
- Jugular pulses absent
- No abdominal distension

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### Diagnostics

#### • Blood pressure

- 108 mmHg (#2 cuff, left front limb)

#### • Chemistry

- BUN 55 (6-30)
- Creatinine 2.1 (0.5-1.5)
- Potassium 3.6 (3.9-5.5)

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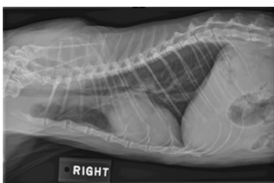
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### Diagnostics

#### • Thoracic Radiographs




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### Summary



- Sphynx cat with unclassified cardiomyopathy
- Responded to parenteral Furosemide initially with minimal response to oral
- Adjustments were made without necessary diagnostic follow up
- Resistance to Furosemide confirmed and a switch to Torsemide was made
- Torsemide is a very potent diuretic, but is useful in cases of refractory (Stage D) CHF.

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